XX. *On the Influence of the Atomic Grouping in the Molecules of Organic Bodies on their Absorption in the Infra-red Region of the Spectrum.*
By Captain ABNEY, *R.E., F.R.S., and Lieut.-Colonel* FESTING, *R.E.*

[PLATES 86–88.]

Introductory.

THE researches on which this paper is founded were commenced in February, 1880, but were not sufficiently advanced for any communication to be made regarding them during last session. As an article on the absorption of colourless liquids by Dr. W. RUSSELL, F.R.S., and Mr. LEPRAIK appeared in 'Nature' on the 19th August, 1880, it might have been thought that we were merely following in the steps of those gentlemen, of the scope of whose work we were not aware; we have therefore stated when our work commenced. It will also be seen that our work has been more especially confined to the infra-red region, for reasons which will presently appear, whilst Messrs. RUSSELL and LEPRAIK turned their attention to the visible portion of the spectrum.

Reasons for undertaking the research.

The investigations of Professor TYNDALL on radiant energy, and its absorption by various organic compounds, led us to believe that if such marked effects were observed by means of the thermopile, at least as much information ought to be gathered from the photographic method recently brought to the notice of the Royal Society.* The absorption measured by the thermopile is essentially the integration of all the absorptions in the different regions of the spectrum examined, and by this method it is almost impossible to determine the position of the several components, since the face of the instrument has an appreciable breadth. By the photographic method not only can an approximate estimate of the amount of absorption exercised by the compound be judged, but the exact localities of such absorptions can be indisputably fixed.

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* Bakerian Lecture "On the Photographic Method of Mapping the least Refrangible End of the Spectrum," by Captain W. DE W. ABNEY, R.E., F.R.S., Phil. Trans., 1880.

It appeared to us that the longer waves of the spectrum would be more likely to be affected by their passage through complex bodies than the shorter waves, and that therefore we ought to look for the absorption effects of the different molecular groupings in such bodies at the least refrangible end of the spectrum.   The absorption spectra of various bodies in the ultra-violet portion of the spectrum have already been photographed by Professors HARTLEY and HUNTINGDON, and whilst that region seems specially adapted for certain series of hydro-carbon compounds, through a diminution or otherwise of the general absorption, &c., special or selective absorptions for all of them apparently lie at the opposite end of the spectrum.   The results which we have tabulated in our maps fully support this view, indicating without much doubt that the substances we have examined can be grouped according to their absorption spectra ; and that such grouping, as far as we have examined it, agrees on the whole with that adopted by chemists.   It would be premature, however, to make any general deductions, since the ground to be covered is co-extensive with the compounds them-selves ; and as we have but made a selection which we believe may be regarded as typical, it will require the patient labour of many for a long period before this new branch of physico-chemical research can be in any way regarded as complete.   We have thought that, by describing our method of work, and by publishing such results as we have already obtained, we might hasten the more extensive research which must eventually be undertaken.   We have therefore the honour to bring the matter before the Society, with a statement that it is our intention as opportunity occurs to continue these investigations.

Apparatus.

Spectroscope.—The spectroscope employed was an excellently planned one by A. HILGER, consisting of three prisms of 62°, and a half prism to which was cemented a right-angled prism for the purpose of reflecting back the rays.   The glass was white flint of medium density.   The beam of light underwent total reflection at the half prism, so that the battery consisted in reality of one, three, five, or seven prisms, as occasion might require.   The great advantage of this arrangement is that when once the camera is in position it does not require readjustment for any movement or alteration in the number of the prisms.   There being, however, occasions when we rather doubted the performance of this arrangement, we adapted the spectroscope to the ordinary form without reflection.   The slit of the spectroscope was furnished with an arrangement by which every third or half only of the aperture need be uncovered at a time.   The collimating lens was of 20 inches focal length, and that of the lens fitted to the camera was of nearly the same, and in some cases of double that length.   The dispersion of three prisms from A to D is about 3° 10′.

Camera.—The camera employed was made by Mr. P. MEAGHER from designs furnished by one of us, and is capable of being employed with any lens whose focal length lies between 9 inches and 6 feet.   It has a horizontal swing back, which is

capable of swinging at a considerable angle to the axis of the lens—a point of importance when it is remembered what a rapid alteration there is in the focus of the rays, as they descend in the infra-red of the spectrum.

Reason for employing glass prisms.—From the nature of the research it was necessary to employ tubes to hold the various liquids, and it would have been impossible to have closed their ends with any material but glass owing to the solvent nature of some of them. From previous experience we knew that the glass used transmitted radiations to a wave-length of at least λ 20,000; and it would have been utterly impossible by prismatic analysis to have distinguished any except very general absorptions even as low down in the spectrum as that wave-length. For these reasons we determined to employ glass prisms. Our results show that in the majority of cases no advantage would have been gained by using rock salt; though for thin layers of vapour we can well imagine that rays of still lower refrangibility would have to be studied.

Number of prisms employed.—Three prisms were invariably employed when photographs were taken from which measurements had to be made. With one or two prisms the dispersion was insufficient to enable the details of the absorption spectra to be accurately observed; though the general character of the absorption was always clearly marked. With five prisms, on the other hand, the absorptions in some cases became too undefined; we therefore concluded that three prisms would be the best number with which to work. In nearly every case, however, photographs of the absorptions were taken with one or two prisms to give a preliminary idea of what we might expect to find with the greater dispersion. It is our intention to pursue the investigation with a diffraction grating, more especially to map the line spectra which have shown themselves.

Measurement of the photographs.—The measurement of the photographs was carefully made by means of a transparent scale applied to the film-side of the negatives, reading to $\frac{1}{4}$ a millimetre by division, and to half that quantity or less by estimation. We attempted to take the measures with a micrometer, but the nature of some of the absorptions precluded its use, since much magnification more or less shrouded the phenomena; with the solar spectrum where the absorptions are in more definite lines as opposed to bands, measurements with a high magnifying power are comparatively easy. The accuracy of our plan of measurement might be doubted, but it is really trustworthy after a little experience. We should not have trusted to it, however, without referring some of the principal spectra to a comparison with the solar spectrum. The wave-lengths of the FRAUNHOFER lines in the infra-red region were taken from the map furnished by one of us with the paper already referred to. A test of the accuracy of the measurements was the fact that the same wave-lengths of the absorption of any particular substance could always be obtained on several photographs.

We invariably compared all absortion spectra with that of ethyl iodide, which

furnishes almost entirely a line spectrum and, in fact, our measurements were referred to an empiric scale derived from the absorptions of this body, before we were fortunate enough to obtain a wave-length scale from strict comparison with the solar spectrum. We believe that the chloroform spectrum might be almost better to give a fiducial scale. The multiplicity of fine lines in both of these substances makes the mapping the spectra comparatively easy when once the position of those lines has been accurately fixed.

Source of light.—In the positive pole of the electric light we have a source of light which may be considered of uniform brightness, if the light emitted from the crater only be employed. Whether the crater be $\frac{1}{8}$ or $\frac{1}{2}$ inch in diameter (the one being produced by a small magneto-electric machine, and the latter by a larger one) the brightness remains constant, being apparently that due to the temperature at which carbon is vaporized. If then an image of the crater be projected on the slit it is evident that the spectrum produced will be a continuous one (crossed, perhaps, in the more refrangible regions by bright lines) and of constant brightness. It is worthy of remark that in no case have we found the continuous spectrum in the least refrangible region to have any signs of bright or dark lines when the crater is projected on the slit. We discuss further on the possibility of any of the lines mapped being due to the carbon vapour in the arc. In order to get as large a portion as possible of the crater available for projection on the slit, the lower pole (which in this case was the positive) was placed slightly behind the upper pole. The electric light we employed was generated by an "M." GRAMME machine, driven by a small three horse-power BROTHERHOOD engine, of whose performance we cannot speak too highly. The current is of such a tension that it is capable of supporting an arc of some $\frac{1}{4}$-inch in length. The lamp employed was a hand-lamp of the SAUTTER LEMONIER's pattern, and for general photographic spectrum work is everything that can be desired. For photographic purposes the radiation emitted from a gas flame is much too feeble to be of any service, and there is no economy in using the oxy-hydrogen light when the electric light is available.

Tubes for holding the liquids.—Tubes of 2 feet, 6 inches, and 3 inches respectively were used for the more common and inexpensive liquids, but for those which were more difficult to obtain and costly the two shorter tubes were invariably used. The longer tubes had diameters of 2 or $1\frac{1}{2}$ inches, and the shorter of $\frac{3}{4}$-inch and $\frac{1}{2}$-inch. In order to get a bright image on the slit, and at the same time to cover the whole aperture, the carbon points were placed about 3 feet from the collimator. The diameter of the condensing lens was about $2\frac{1}{2}$ inches, which thus just cast a beam sufficient to fill the collimating lens. The smaller tubes were placed in the position where the rays crossed, and thus when they were interposed before the slit the brightness suffered no diminution except that due to the liquid itself.

Photographic arrangements.

Exposures.—The exposures were arranged in accordance with what experience taught us was the best time for different lengths of tube and differing liquids. In every case photographs were taken of each compound with varying lengths of exposure, in order to ascertain which gave the most trustworthy and measurable results. On the one hand, it was necessary to show the detail in those parts which had no general absorption but in which there was special absorptions; and, on the other hand, it was necessary to show the special absorptions in those regions which had general absorption superposed. These details were often obtained by means of one or more photographs. It had also to be remembered that the silver salt employed, though sensitive, it is believed, to the extreme theoretical limit of the prismatic spectrum, yet has one maximum of sensitiveness, situated a little below the limit of the visible spectrum, from which point the "curve of sensitiveness" gradually falls away on each side. Thus, with an unabsorbed continuous spectrum it would require about three times more exposure for λ 12,000 to impress the film to develop to a standard density than it would for λ 8000. This difficulty is, however, met with at the other end of the spectrum, where the usual photographic plates are employed, and is necessarily present in all spectrum photography.

Precautions to be observed.—There are a few cautions to give to other observers—first, to ascertain that the floor of the laboratory is free from vibration; second, to get an accurate focus of the locality near λ 900; third, to set the prisms at an angle of minimum deviation for that locality, since in that region the greatest variations in the absorption phenomena are to be found; fourth, to use a good reference spectrum, such as that of chloroform; and, fifth, to see that the tubes are accurately centered with the axis of the collimating tube.

Mapping the results.

In order to map the results in wave-lengths, photographs of the solar spectrum were made with the same spectroscope as that employed in the research, and the FRAUNHOFER lines accurately measured and laid down to scale. The wave-lengths, also to scale, were erected as ordinates and a curve constructed. The value for every 10 in the wave-length scale was then found on the curve and fresh ordinates plotted from these points on the curve, and this was our "prismatic scale." When plotting an absorption spectrum the distance between two known points was noted off on a convenient ivory scale, and this applied to the ordinates of the prismatic scale at the known wave-lengths. All intermediate points could then be immediately read off in wave-lengths. The wave-lengths between 900 and 1000 we consider to be accurate to within one or two, and beyond that point to within three or four; the shorter wave-lengths are accurate within one, we believe.

Substances examined.

We append a list of substances the absorption spectra of which we have mapped on an empiric scale reduced to wave-lengths subsequent to the reading of the paper, but it must not be inferred that these are all that we have examined. There are various aqueous solutions which we have not dealt with in this paper, preferring to eliminate as far as possible any matter which did not seem to bear directly on the objects we had in view. We have, in addition to the map, made a tabular statement of each spectrum, inserting approximate wave-lengths, which we trust will be of use to future observers.

Different kinds of absorption.

It may be useful to state the different kinds of absorption with which we have met. 1st. General absorption from the least refrangible end.

2nd. Special absorptions
$$\begin{cases} \text{Lines} \begin{cases} \text{fuzzy, or} \\ \text{sharp.} \end{cases} \\ \text{Bands} \begin{cases} \text{both edges sharply defined.} \\ \text{one edge sharply defined.} \\ \text{both edges not sharply defined.} \end{cases} \end{cases}$$

Regarding the general absorption we have nothing very noteworthy to remark, beyond the fact that as a rule in the hydrocarbons of the same series those of heavier molecular constitution seem to have less than those of lighter.

In regard to the special absorptions we may say that it is very often easy to distinguish the position of lines at the edges of bands, though they are not sufficiently marked to be represented on the map. This is more noteworthy, when we have a change from a very dense absorption to a feebler one. The impression left on the mind is that in reality these particular bands are made up of lines of different intensities, but of this we cannot speak with authority.

As to the possibility of any of these special absorptions being due to the carbon vapour, &c., of the arc, it will, we think, be sufficient to state that, as we do not find any trace of them in photographs taken without a liquid in front of the slit, we are quite satisfied that they can be due only to the substances with which we have experimented.

Nature of the absorptions.

As regards the nature of the absorptions caused by the different substances experimented on, we started with no preconceived idea—we simply mapped what we measured. In our earlier photographs, which were of substances containing oxygen, we found the absorptions to be mostly in bands and irregularly-placed and ill-defined lines, the want of definition we now know being caused by maladjustment of the focus and a want of rigidity in our laboratory floor. It was not until we had removed our

apparatus to a more stable site, and till we examined some of the iodides of the alcohol series, that we observed many sharply-defined lines and also that the edges of the bands were more rigidly marked ; and when it appeared that some of the edges of the bands in the compounds containing oxygen were coincident with some of the fine lines in the iodides, we were forced to the conclusion that there must be some connexion between the one and the other, since such an agreement could not be fortuitous. Our endeavour was therefore to discover, if possible, what constituents of the iodides caused these lines. They must be due to carbon, iodine, or hydrogen, or to a combination of one with the other.

Our first step was to get a substance which should contain but one atom of carbon and one of hydrogen, and this we found in chloroform. On examining the photograph of this spectrum we were gratified to find that all bands had disappeared, and that the absorption spectra contained only lines, some fine and some broad. By reducing, then, the carbon and hydrogen and increasing the halogen a line spectrum was produced.

It seemed possible, nay, probable, that these lines might be due to the chlorine present in such abundance in the chloroform, and if so it was evident that by abstracting the last atom of hydrogen and taking carbon tetrachloride an absorption spectrum of a still simpler form, but still lineal, should be obtained. To our surprise, however, we found that the absorption of carbon tetrachloride was an absolute blank, and that there was no absorption beyond a slight general one at the least refrangible end of the infra-red. With carbon disulphide the same negative result was also obtained.

This seemed to show that neither chlorine nor carbon had anything to do with the linear spectrum observed in chloroform. Dr. HODGKINSON kindly prepared for us a solution of cyanogen in carbon tetrachloride (180 vols. of gas in one of the solvent), and not a trace of line or band was found in its spectrum. A crucial test was to observe spectra containing hydrogen and chlorine, hydrogen and oxygen, and hydrogen and nitrogen.

We therefore tried hydrochloric acid and obtained a spectrum containing some few lines. Water gave lines, together with bands, two lines being coincident with those in the spectrum of hydrochloric acid.

In ammonia, nitric acid, and sulphuric acid we also obtained sharply-marked lines, coincidences in the different spectra being observed, and nearly every line mapped found its analogue in the chloroform spectrum, and usually in that of ethyl iodide. Benzine again gave a spectrum consisting principally of lines, and these were coincident with some lines also to be found in chloroform. It seems then that the hydrogen, which is common to all these different compounds, must be the cause of the linear spectrum. In what manner the hydrogen annihilates the waves of radiation at these particular points is a question which is at present, at all events, an open one, but that the linear absorptions, common to the hydrocarbons and to those bodies in which hydrogen is in combination with other elements such as oxygen and nitrogen, is due to hydrogen there can be no manner of doubt.

We may go a step further than this, however. We find both edges of some
bands to accord with the position of known hydrogen lines, whilst in others we find
that only one edge can be so marked. Though direct evidence is wanting to enable
us to say that the other edge marks the position of a hydrogen line, yet the circum-
stantial evidence that such is the case is excessively strong. In point of fact, of the
hydrogen lines and edges of bands to be found in hydrocarbons lying between 900
and 972 of our empiric scale, more than half are to be found coincident with lines in
the non-carbon bodies. The following table shows the coincidences :—

Hydrocarbons	900	902	905	910	912	920	927	935	942	949	952	959	972
Hydrogen and oxygen, or nitrogen, or chlorine	900	..	..	..	912	920	927	..	..	949	..	959	972

On the more refrangible side of 900 the coincidences in the latter series are always
to be found in the former. If other bodies containing no carbon be examined no
doubt some of the gaps in the table will be filled up. It must distinctly be understood
that in all the absorptions in which bands, lines, or both appear, the position of the
whole of the known hydrogen lines will not be found, each weighted radical making a
selection of them.

Effect of the presence of oxygen.

It is seen that bodies containing carbon and hydrogen alone or with chlorine,
bromine, or iodine, gave absorption spectra in which there are defined bands together
with lines.

The next point that required solution was the effect of the presence of oxygen on
the body under examination, and here we had ample material on which to make our
observations. It appears that in every case where oxygen is present otherwise than
as a part of the radical it is attached to some hydrogen atom in such a way that it obli-
terates the radiation between two of the lines which are due to that hydrogen. Take,
for example, ethyl alcohol. We find that one band of absorption takes place between
927 and 942, another between 900, and 905 on the less refrangible, and 892 on the
more refrangible side. Now, all these different numbers are localities where hydrogen
lines are to be found. Iso-butyl alcohol is another good example. Besides the last-
named bands of the ethyl alcohol it has bands lying between 912 and 920, between
927 and 942, and a narrow band about 959. These, again, are all localities where
hydrogen lines can exist. If more than one hydroxyl group be present we doubt if
any different effect is produced beyond that produced by one hydroxyl group, except
a possible greater general absorption ; a good example of this will be found in cinnamic
alcohol and phenyl-propyl alcohol, which give the same spectra as far as the special
absorptions are concerned.

Effect of increase or diminution in the length of the absorbing medium.

A natural question to ask is as to the effect of the increase or the diminution in length of the compound placed before the slit of the spectroscope. The answer is not difficult to give. Where an increase of length is used, one of two things occurs : either general absorption creeps up further towards the more refrangible end, or the absorption features are more marked. It may be supposed that in the latter case the bands should become more defined, but this is not so ; the bands, as the length of column of liquid increases, may spread out till they reach the locale of another hydrogen band, each line becoming, as it were, a stepping stone for a further advance of absorption. This usually takes place only on the more refrangible edge of a band, the less refrangible edge remaining, as a rule, constant. In some cases both edges of the band remain fixed (as example we may quote the ethyl alcohol band situated about 900) and neither increase nor diminution of length of fluid alters their relative positions.

Where the length of column is diminished one of three things happens : the absorption disappears altogether, the bands fade into the lines bounding one of their edges, or they become fainter and remain constant. At the edge of the band which is least defined the absorption gradually disappears till a line is left at the most defined edge, or if both are ill-defined the nucleus will probably be found to be central to it. When both edges are well-defined the band remains constant in width, but fainter.

Oxygen combined in the radical.

Hitherto we have only taken into account oxygen which is not contained in the radical ; when it is so contained it appears to act differently, always supposing hydrogen to be present as well. We need only refer to the spectrum of aldehyde which is inclined to be linear rather than banded, or rather the bands are bounded by absolute lines, and are more defined than when oxygen is more loosely bonded.

Detection of the radical.

An inspection of our maps will show that the radical of a body is represented by certain well-marked bands, some differing in position according as it is bonded with hydrogen, or a halogen, or with carbon, oxygen, or nitrogen. There seem to be characteristic bands, however, of any one series of radicals between 1000 and about 1100, which would indicate what may be called the central hydrocarbon group, to which other radicals may be bonded.

The clue to the composition of a body, however, would seem to lie between λ 700 and λ 1000. Certain radicals have a distinctive absorption about λ 700 together with others about λ 900, and if the first be visible it almost follows that the distinctive mark of the radical with which it is connected will be found. Thus in the ethyl series we find

an absorption at 740, and a characteristic band one edge of which is at 892, and the other at 920.   If we find a body containing the 740 absorption and a band with the most refrangible edge commencing at 892, or with the least refrangible edge terminating at 920, we may be pretty sure that we have an ethyl radical present.   So with any of the aromatic group; the crucial line is at 867.   If that line be connected with a band we may feel certain that some derivative of benzine is present.   The benzyl group show this remarkably well, since we see that phenyl is present, as is also methyl.   It will be advantageous if the spectra of ammonia, benzine, aniline, and dimethyl aniline be compared, when the remarkable coincidences will at once become apparent, as also the different weighting of the molecule.   The spectrum of nitro-benzine is also worth comparing with benzine and nitric acid.   We should have liked to have said more regarding the detection of the different radicals, but it might seem presumptuous on our part to lay down any general law on the results of the comparatively few compounds which we have examined.   In our own minds there lingers no doubt as to the easy detection of any radical which we have examined, but it will require more energy and ability than we possess to thoroughly classify all the different modifications which may arise.

We may say, however, it seems highly probable by this delicate mode of analysis that the hypothetical position of any hydrogen which is replaced may be identified, a point which is of prime importance in organic chemistry.

The detection of the presence of chlorine or bromine or iodine in a compound is at present undecided, and it may well be that we may have to look for its effects in a different part of the spectrum.   The only trace we can find at present is in ethyl bromide, in which the radical band, about 900, is curtailed in one wing.   The difference between amyl iodide and amyl bromide is not sufficiently marked to be of any value.   We quit this part of our subject in the hope that chemists will be able to help us to decipher more than has as yet been done.

Solar coincidences.

We have already stated that in order to determine the wave-lengths of the absorptions in the different spectra, we have taken photographs of the solar spectrum on the same plate with that of a few of the principal substances.   Unfortunately, when at first we took up the iodides we had no opportunity of thus obtaining a direct comparison between the FRAUNHOFER lines and ethyl iodide; but as a matter immediately affecting our results this has nothing to do, since all the substances mapped are mapped in reference to ethyl iodide.   When our maps were at the point of completion, and in fact when all the measurements but two or three had been made, it struck us that we might find some analogy between the solar spectrum of this region and our linear absorptions, since these are presumably due to hydrogen.   At that time we noted several of what appeared to be coincidences

between the absorptions in the organic compounds and in the solar spectrum. Since the reading of the paper* we have further investigated these coincidences with greater prismatic dispersion and also with a diffraction grating of 17,260 lines to the inch. The indubitable result is that the broad line in the solar spectrum at λ 866 is coincident with the radical line of benzine which in our scale is 856. Comparing the ethyl iodide group with the solar spectrum we find that the following bands are coincident with bands or lines in the solar spectrum: 880 to 888 with λ 895 to λ 903, 888 to 892 with λ 904 to 907, 898 to 902 with λ 913 to 918, 902 to 912 with λ 927 to 930·5, 912 to 920 with λ 932 to 942. These bands are essentially the radical bands of the ethyl series. There are some more apparent solar coincidences in the spectra of water and chloroform. It is very remarkable that the line 856 in our scale should be the basic lines of the benzine series. When the thickness of benzine is gradually diminished this is the last line which disappears, but it remains of constant breadth to the end. Should it appear by subsequent investigations that the ethyl radical is really to be found in the solar spectrum it might be due to acetylene, from which immediately would follow the formation of benzine.

Again, anyone who looks at a photograph of the solar A band and that of benzine, must be struck with the close structural likeness between the two; it would not be at all surprising to find that λ 760 was another nucleus for a hydrocarbon group.

The X group of lines in the solar spectrum and that of the groups already mentioned appears to one of us to remain of constant intensity at any elevation of the sun or in any state of the intermediate atmosphere. It may therefore be necessary to refer them to some absorbing medium lying at the sun itself, or beyond the usually accepted limits of our atmosphere. Be it where it may, the fact remains that, in two instances at least, a study of the absorption spectra of organic bodies has to some extent thrown a glimmering of meaning on some of the absorption lines of the solar spectrum.

The value of a study of the absorption spectra of liquids (not including in this term solids in solution) in order to gain an insight into their molecular constitution has been demonstrated by Professors HARTLEY and HUNTINGDON, and by their organized attack they have thrown much light on the subject; but we venture to think that the results we have obtained will prove that in these absorptions a still greater insight into the molecular constitutions of such bodies may be given. We may be too sanguine, but we believe not. It seems to us that the spectra leave as definite characters to read as are to be found in hieroglyphics, and we venture to think that we have given a clue to enable them to be deciphered. As to our theory that the foundation of all absorptions in these bodies is the hydrogen, we are content to leave it for discussion. If it should prove unreliable, the *clue* alone to the characters must be sought elsewhere: the story is still to be read by any one who may find a better one and a truer. Fully conscious of this, we would invite an exhaustive discussion, deeming that the results alone, which are indisputable, will give a ready basis for it.

* March, 1881.

In conclusion, we have to say that we are indebted to Dr. FRANKLAND, Dr. ARM-STRONG, Dr. RUSSELL, and Dr. GUTHRIE for several organic substances ; but to Dr. HODGKINSON are our thanks especially due for the ready manner in which he lent us many choice specimens of his own preparation, and for the kind advice he was at all times ready to offer us (and which we freely accepted) as to the kind of compound to examine which would most aid us at any particular stage of our research. It is almost superfluous to mention that our work has been largely aided in the preparation of photographic material by Sergeant JACKSON, R.E., and we take this opportunity of thanking him for the least interesting portion of the work which he so willingly carried out for us. The labour may be appreciated when it is considered that many hundreds of photographs have been taken, some 300 of which have been measured and compared. A research of this kind is always arduous, but it has been lightened by the cordial cooperation of those whom we have named. Our thanks are also due to Mr. DICK for the careful way in which he has drawn our maps.

APPENDIX.

The following appendix contains a tabular statement* of all the lines and bands measured in the different compounds mapped ; where not otherwise expressly stated, 6 inches was the length of the column of liquid used.

The intensities of the lines have been taken as 1, $\frac{3}{4}$, $\frac{1}{2}$, and $\frac{1}{4}$: the first-named intensity signifying total transparency in the photographs. When an intensity is shown as $\left.\begin{array}{c} 0 \text{ to } 1 \\ 1 \text{ to } 0 \end{array}\right\}$ it means that there is a gradually increasing intensity of absorption between the first-named edge of a band and the centre of it, and that it decreases at an equal rate on the other side of the centre to the second-named edge of the band. When a band is shown as of one intensity (say $\frac{1}{2}$), it means that the whole of that band has an equal intensity throughout. When it is shown as (say) 0 to 1 it means that the intensity increases from 0 at the first edge of the band and terminates abruptly at the second edge. These explanations, it is believed, will suffice to make the appendix clear. The sources from whence the substances analysed were obtained are shown in the tables.

* The approximate wave-lengths have been added since the paper was read, March, 1881.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Methyl alcohol (KAHLBAUM).	867	857 L	$\frac{1}{2}$	
	905 } 913 }	890 } 898 } B	$\frac{1}{4}$	
	913 } 917 }	898 } 902 } B	1	
	917 } 926 }	902 } 908 } B	$\frac{3}{4}$	
	926 } 930 }	908 } 912 } B	1	
	930 } 942 }	912 } 920 } B	$\frac{3}{4}$	
	942 } 949 }	920 } 927 } B	1	
	972	947 L	1	
	985	959	1	Broad line.
	985 } 1017 }	959 } 985 } B	$\frac{1}{2}$	
	1017 } 1020 }	985 } 987 }	$\frac{1}{2}$ to 1	
Ethyl alcohol (KAHLBAUM).	741	740 L	$\frac{1}{2}$	Fuzzy line.
	885	872 L	$\frac{1}{2}$	
	907 } 922 }	892 } 905 } B	{ 0 to 1 } { 1 to 0 }	1 is reached about 902.
	949	927 L	1	
	949 } 967 }	927 } 943 } B	0 to 1	
	985	959 L	1	Broad.
	986 } 1153 }	960 } 1090 } B	$\frac{1}{2}$	
	1066	1025 B	1	As in ethyl iodide.
	1086	1037 B	1	,, ,,
	1135	1072 B	1	,, ,,
	1165	1100	1	End of spectrum.
Propyl alcohol (KAHLBAUM).	746	745 L	$\frac{1}{2}$	Broad line.
	895	880 L	$\frac{1}{2}$	
	908 } 913 }	892 } 898 } B	0 to $\frac{1}{4}$	
	913 } 917 }	898 } 902 } B	1	
	917 } 942 }	902 } 920 } B	1 to 0	
	985	959 L	B	
	985 } — }	959 } 1160 } B	$\frac{1}{2}$	
	1040	1003 B	1	As in ethyl iodide.
	1066	1025 B	1	,, ,,
	1086	1037 B	1	,, ,,
	1135	1072 B	1	,, ,,
	1165	1100 B	1	,, ,,

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Isopropyl alcohol (Kahlbaum).	741	740 L	$\frac{1}{2}$	Fuzzy, extending from 734 to 742.
	885	872 L	$\frac{1}{2}$	
	907 } 922 }	892 } 905 } B	0 to 1 1 to 0	As in ethyl alcohol.
	949 } 966 }	927 } 942 } B	0 to 1	
	985	959 L	1	Broad line.
	1040	1003 L	1	„ „
	1040 } 1061 }	1003 } 1020 } B	0 to 1	
	1061	1020	1	End of spectrum.
Pseudo butyl (Kahlbaum).	735	735 L	$\frac{1}{2}$	
	741 } 746 }	740 } 745 } B	$\frac{1}{2}$	
	895	880 L		
	907 } 913 }	892 } 898 } B	0 to $\frac{1}{2}$	
	913 } 922 }	898 } 905 } B	1	
	930 } 942 }	912 } 920 } B	1	
	949 } 966 }	927 } 942 } B	1	
	985	959 L	1	Broad.
	1020 } 1066 }	987 } 1025 } B	0 to $\frac{1}{2}$	
	1066 } — }	1025 } 1200 }	$\frac{1}{2}$	
	1066	1025 B	1	As in ethyl iodide.
	1087	1038 B	1	„ „
	1165	1100 B	1	„ „
	—	1200 L	1	End of spectrum.
Isobutyl (Kahlbaum).	741 } 748 }	740 } 747 } B	$\frac{1}{2}$	
	895	880 L		
	907 } 904 }	892 } 889 } B	0 to $\frac{1}{2}$	
	913 } 922 }	898 } 905 } B	1	
	930 } 942 }	912 } 920 } B	1	
	949 } 966 }	927 } 942 } B	1	
	985	959 L	1	Broad.
	1020	987 L	1	
	1020 } 1036 }	987 } 1000 } B	0 to 1	
	1036	1000	1	End of spectrum. [With prolonged exposure traces of bands at 925, 937, 972, and 1100 are visible.]

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Amyl alcohol (FRANKLAND).	753	752 L	$\frac{1}{2}$	
	893	878 L	$\frac{1}{2}$	
	913 ⎱ 923 ⎰ B	898 ⎱ 905 ⎰ B	$\frac{1}{2}$	
	923 ⎱ 927 ⎰ B	905 ⎱ 910 ⎰ B	1	
	927 ⎱ 942 ⎰ B	910 ⎱ 920 ⎰ B	$\frac{1}{2}$	
	949 ⎱ 973 ⎰ B	927 ⎱ 948 ⎰ B	{ 0 to $\frac{3}{4}$ { $\frac{3}{4}$ to 0	
	973 ⎱ 985 ⎰ B	948 ⎱ 959 ⎰ B	$\frac{1}{4}$	
	985 ⎱ 994 ⎰ B	959 ⎱ 967 ⎰ B	0 to $\frac{3}{4}$	
	994 ⎱ 1002 ⎰ B	967 ⎱ 972 ⎰ B	$\frac{3}{4}$	
	1002	972 L	1	Broad line.
	1020	987 L	1	,, ,,
	1066	1025 B	1	As in ethyl iodide.
	1087	1038 B	1	,, ,,
	1135	1072 B	1	,, ,,
	1165	1100 B	1	
	1066 ⎱ — ⎰ B	1025 ⎱ 1160 ⎰ B	$\frac{1}{2}$	Background.
	—	1160 ⎱ 1180 ⎰	$\frac{1}{2}$ to 1	,, ,,
	—	1180	1	End of spectrum.
Methyl iodide (KAHLBAUM).	720	722 L	1	Broad with nucleus.
	867	857 L	1	This line forms a nucleus between a band of $\frac{1}{2}$ intensity extending from 852 to 862.
	885 ⎱ 892 ⎰ B	872 ⎱ 878 ⎰ B	0 to 1	
	892 ⎱ 899 ⎰ B	878 ⎱ 884 ⎰ B	1	
	915	900 L	1	Very fine.
	1020	987 L	1	Broad.
	1040	1003 L	1	Broader.
	1066	1025 B	1	As in ethyl iodide.
	1086	1037 B	1	,, ,,
	1135	1072 B	1	,, ,,
	1165	1100 B	1	,, ,,
	1066 ⎱ — ⎰ B	1025 ⎱ 1120 ⎰ B	$\frac{1}{2}$	
	—	1120 ⎱ 1140 ⎰ B	$\frac{1}{2}$ to 1	
	—	1140	1	End of spectrum.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Ethyl iodide, standard (FRANKLAND).	732	732 L	1	Broad with nucleus.
	741	740 L	$\frac{1}{2}$	
	774	772 L	$\frac{1}{4}$	
	782	778 L	$\frac{1}{4}$	
	813	808 L	$\frac{1}{4}$	
	833	824 L	$\frac{1}{4}$	
	867	857 L	1	N.B.—From 1025 to 1180 the background is $\frac{1}{2}$ and from 1180 to 1200 0 to 1, near which point is end of spectrum.
	895, 903 } B	880, 888 } B	0 to 1	
	903, 907 } B	888, 892 } B	1	
	913, 918 } B	898, 902 } B	1	
	928, 930 } B	908, 912 } B	1	
	930, 942 } B	912, 920 } B	1 to 0	
	949	927 L	$\frac{1}{2}$	
	958	935 L	$\frac{1}{2}$	
	966	942 L	$\frac{1}{2}$	
	972	947 L	$\frac{1}{2}$	
	977	952 L	$\frac{1}{2}$	
	985	959 L	1	
	1002	972 L	1	Broad.
	1020	987 L	1	„
	1040	1003 L	1	Broader.
	1061, 1075 } B	1020, 1030 } B	{ $\frac{1}{2}$ to 1 / 1 to $\frac{1}{2}$	
	1082, 1093 } B	1035, 1042 } B	{ $\frac{1}{2}$ to 1 / 1 to $\frac{1}{2}$	
	1124, 1143 } B	1065, 1078 } B	{ $\frac{1}{2}$ to 1 / 1 to $\frac{1}{2}$	
	1160, 1171 } B	1095, 1105 } B	1 to 1	
Ethyl bromide (KAHLBAUM).	..	..	..	This spectrum is the same as ethyl iodide, except that the bands 908 to 912, and 912 to 920 are replaced by—
	926, 933 } B	908, 914 } B	1	
	933, 942 } B	914, 920 } B	$\frac{1}{4}$	

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Propyl iodide (KAHLBAUM).	732	732 L	$\frac{1}{2}$	
	746	745 L	$\frac{1}{2}$	
	867	857 L	$\frac{1}{2}$	
	902 } 910 }	886 } 895 } B	{ 0 to 1 / 1 to 0 }	
	917 } 925 }	902 } 907 } B	{ 0 to 1 / 1 to 0 }	
	947 } 966 }	927 } 942 } B	{ 0 to 1 / 1 to 0 }	
	985	959 L	$\frac{1}{2}$	
	1002	972 L	$\frac{1}{2}$	
	1020	987 L	1	As in ethyl iodide.
	1040	1003 L	1	„ „
	1066 } — }	1025 } 1160 } B	$\frac{1}{2}$	
	1066	1025 B	1	„ „
	1087	1038 B	1	„ „
	1135	1072 B	1	„ „
	1165	1100 B	1	„ „
Amyl iodide or amyl bromide (KAHLBAUM).	732	732 L	$\frac{1}{2}$	} Shade $\frac{1}{4}$ between these lines.
	752	751 L	$\frac{1}{2}$	
	867	857 L	$\frac{1}{2}$	
	886	872 L	$\frac{1}{2}$	
	895 } 907 }	880 } 892 } B	$\frac{1}{2}$	
	917 } 930 }	902 } 912 } B	1	
	930 } 942 }	912 } 920 } B	$\frac{1}{2}$	
	957 } 971 }	935 } 947 } B	{ 0 to 1 / 1 to 0 }	
	1020	987 L	$\frac{1}{2}$	
	1040	1003 L	$\frac{1}{2}$	Broader.
	1066	1025 B	1	As in ethyl iodide.
	1086	1037 B	1	„ „
	1135	1072 B	1	„ „
	1165	1100 B	1	„ „
	1066 } — }	1025 } 1200 } B	$\frac{1}{2}$	
Hexyl iodide (KAHLBAUM).	748	747 L	$\frac{1}{2}$	
	867	857 L	$\frac{1}{2}$	
	886	872 L	$\frac{1}{2}$	
	900 } 907 }	884 } 892 } B	0 to $\frac{3}{4}$	
	907	892 L	1	} Shade between these lines.
	915	900 L	1	
	915 } 966 }	900 } 942 } B	$\frac{3}{4}$ to 0	Gradual shade.
	947	927 L	$\frac{3}{4}$	
	1020	987 L	$\frac{1}{2}$	
	1020 } 1061 }	987 } 1020 } B	0 to $\frac{1}{2}$	
	1040	1003 L	$\frac{3}{4}$	
	1066	1025 B	1	As in ethyl iodide.
	1087	1038 B	1	„ „
	1135	1072 B	1	„ „
	1165	1100 B	1	„ „

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Aldehyde (Kahlbaum).	732	732 L	$\frac{1}{2}$	Rather a fuzzy line.
	867	857 L	$\frac{1}{2}$	
	895 ⎫ 907 ⎭	880 ⎫ 892 ⎭ B	⎧ 0 rapid to $\frac{1}{2}$ and ⎨ thence gradual ⎩ to $\frac{3}{4}$ at 892	
	911 ⎫ 925 ⎭	895 ⎫ 908 ⎭ B	⎧ Steep from 0 to $\frac{3}{4}$, ⎨ gradual to $\frac{1}{2}$, and ⎩ steep to 0	
	947	927 L	$\frac{1}{2}$	
	971 ⎫ 1020 ⎭	947 ⎫ 987 ⎭ B	⎧ Band shaded ⎪ equally 0 to $\frac{1}{2}$ ⎨ and $\frac{1}{2}$ to 0, 959 L ⎩ $\frac{3}{4}$	
	985	959 L		
	1020	987 L	$\frac{3}{4}$	
	1040 ⎫ 1090 ⎭	1003 ⎫ 1040 ⎭ B	⎧ Shaded equally ⎨ from 0 to $\frac{1}{2}$ and ⎩ $\frac{1}{2}$ to 0	
	1047 ⎫ 1061 ⎭	1010 ⎫ 1020 ⎭ B	1	⎧ This band appears ⎨ through the wider ⎩ previous band.
	1135	1072 B	1	⎧ A band as in ethyl ⎩ iodide.
	1165	1100 B	1	N.B.—From 1040 to 1120 background $\frac{1}{4}$, and end of spectrum at 1160.
Paraldehyde (Kahlbaum).	732	732 L	$\frac{1}{2}$	
	867	857 L	$\frac{1}{2}$	
	895 ⎫ 913 ⎭	880 ⎫ 898 ⎭ B	⎧ 0 to 1 at 892 ⎩ 1 to 0 at 898	
	980 ⎫ to 1177 ⎭	955 ⎫ to 1110 ⎭ B	⎧ Gradual shade of ⎨ background 0 to ⎩ $\frac{3}{4}$	
	980 ⎫ 992 ⎭	955 ⎫ 963 ⎭ B	⎧ 0 to $\frac{1}{2}$ ⎩ $\frac{1}{2}$ to 0	
	983	959 L	1	
	998 ⎫ 1004 ⎭	970 ⎫ 974 ⎭ B	⎧ 0 to $\frac{1}{2}$ ⎩ $\frac{1}{2}$ to 0	
	1001	972 L	1	
	1040	1003 L	1	
	1040 ⎫ 1061 ⎭	1003 ⎫ 1020 ⎭ B	⎧ 0 to 1 ⎩ 1 to 0	
	1061	1020 L	1	
	1090 ⎫ 1103 ⎭	1040 ⎫ 1050 ⎭ B	⎧ 0 to 1 ⎩ 1 to 0	
	1143 ⎫ 1156 ⎭	1080 ⎫ 1090 ⎭ B	⎧ 0 to 1 ⎩ 1 to 0	
	1162 ⎫ 1171 ⎭	1095 ⎫ 1105 ⎭ B	⎧ 0 to 1 ⎩ 1 to 0	
	1177	1110	1	End of spectrum.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Diethyl ether (HOPKIN and WILLIAMS).	741	740 L		
	907 } 920 }	892 } 903 } B	1	
	958 } 985 }	935 } 959 } B	0 to 1	
	1040 } 1075 }	1003 } 1030 } B	{ 0 to 1 / 1 to 0 }	} 1 at 1025.
	1086	1037 B	1	As in ethyl iodide.
	1135	1072 B	1	,, ,,
	1165	1100 B	1	,, ,,
	1075 } — }	1030 } 1130 } B	$\frac{1}{2}$	Background.
	— } — }	1130 } 1140 } B	$\frac{1}{2}$ to 1	
	—	1140	1	End of spectrum.
Amyl ether (KAHLBAUM).	753	751 L	$\frac{1}{2}$	
	893	878 L	$\frac{1}{2}$	
	913 } 922 }	898 } 905 } B	$\frac{1}{2}$	
	922 } 927 }	905 } 910 } B	1	
	927 } 942 }	910 } 920 } B	$\frac{1}{2}$	
	942 } 949 }	920 } 927 } B	$\frac{1}{2}$ to 0	
	966 } 1002 }	942 } 972 } B	{ 0 to 1 / 1 to 0 }	
	1040	1003 L	1	Broad.
	1066	1025 L	1	As in ethyl iodide.
	1040 } 1066 }	1003 } 1025 } B	$\frac{1}{4}$	
	1066 } — }	1025 } 1175 } B	$\frac{1}{2}$	
	1139 } 1150 }	1075 } 1085 } B	{ 0 to 1 / 1 to 0 }	
	1165	1100 B	1	As in ethyl iodide.
	— } — }	1175 } 1180 } B	$\frac{1}{2}$ to 1	
	—	1180	1	End of spectrum.

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Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Ethyl nitrate (KAHLBAUM).	741	740 L	$\frac{1}{2}$	
	873	862 L	$\frac{1}{2}$	
	896 ⎱ 907 ⎰	882 ⎱ 892 ⎰ B	$\frac{1}{4}$	
	907 ⎱ 915 ⎰	892 ⎱ 900 ⎰ B	1	
	952 ⎱ 963 ⎰	930 ⎱ 940 ⎰ B	{ 0 to $\frac{3}{4}$ / $\frac{3}{4}$ to 0	
	996 ⎱ 1006 ⎰	968 ⎱ 976 ⎰ B	{ 0 to $\frac{3}{4}$ / $\frac{3}{4}$ to 0	
	1020	987 L	$\frac{1}{2}$	
	1036 ⎱ 1051 ⎰	1000 ⎱ 1013 ⎰ B	{ 0 to $\frac{3}{4}$ / $\frac{3}{4}$ to 0	
	1096 ⎱ 1108 ⎰	1045 ⎱ 1053 ⎰ B	{ 0 to $\frac{3}{4}$ / $\frac{3}{4}$ to 0	
	1159 ⎱ 1171 ⎰	1095 ⎱ 1105 ⎰ B	{ 0 to $\frac{3}{4}$ / $\frac{3}{4}$ to 0	
	1040 ⎱ — ⎰	1003 to 1160 ⎰ B	$\frac{1}{2}$	
	—	1160 ⎱ 1165 ⎰ B	$\frac{1}{2}$ to 1	
	—	1165	1	End of spectrum.
Ethyl oxalate (HODGKINSON.)	741	740 L	$\frac{1}{2}$	
	873	862 L	$\frac{1}{2}$	
	896 ⎱ 907 ⎰	882 ⎱ 892 ⎰ B	0 to $\frac{1}{2}$	
	907 ⎱ 915 ⎰	892 ⎱ 900 ⎰ B	1	
	952 ⎱ 963 ⎰	930 ⎱ 940 ⎰ B	{ 0 to $\frac{3}{4}$ / $\frac{3}{4}$ to 0	
	1036 ⎱ 1051 ⎰	1000 ⎱ 1013 ⎰ B	{ 0 to $\frac{3}{4}$ / $\frac{3}{4}$ to 0	
	1096 ⎱ 1110 ⎰	1045 ⎱ 1055 ⎰ B	{ 0 to $\frac{3}{4}$ / $\frac{3}{4}$ to 0	
	1159 ⎱ 1171 ⎰	1095 ⎱ 1105 ⎰ B	{ 0 to $\frac{3}{4}$ / $\frac{3}{4}$ to 0	
	952 ⎱ — ⎰	930 ⎱ 1160 ⎰ B	$\frac{1}{2}$	
	—	1160 ⎱ 1165 ⎰ B	$\frac{1}{2}$ to 1	
	—	1165	1	End of spectrum.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Ethyl sulphide (FRANKLAND).	741	740 L	1	
	867	857 L	1	
	886	872 L	$\frac{1}{2}$	
	907 ⎫ 913 ⎬	892 ⎫ 898 ⎬ B	0 to $\frac{3}{4}$	
	913 ⎫ 917 ⎬	898 ⎫ 902 ⎬ B	1	
	917 ⎫ 922 ⎬	902 ⎫ 905 ⎬ B	$\frac{3}{4}$ to $\frac{1}{2}$	
	922 ⎫ 942 ⎬	905 ⎫ 920 ⎬ B	$\frac{1}{2}$ to 0	⎰ The shade from $\frac{1}{2}$ com- mences about 919.
	1030 ⎫ 1075 ⎬	995 ⎫ 1030 ⎬ B	0 to $\frac{1}{2}$	
	1040	1003 L	1	
	1061 ⎫ — ⎬	1020 ⎫ 1160 ⎬ B	$\frac{1}{2}$	
	1067	1025 B	1	As in ethyl iodide.
	1087	1038 B	1	,, ,,
	1135	1072 B	1	,, ,,
	1165	1100 B	1	,, ,,
	—	1160	1	End of spectrum.
Amyl nitrite (GUTHRIE).	753	752 L	$\frac{1}{2}$	
	886	872 L	$\frac{1}{2}$	
	907 ⎫ 915 ⎬	892 ⎫ 900 ⎬ B	$\frac{1}{2}$	
	915 ⎫ 928 ⎬	900 ⎫ 910 ⎬ B	1	
	928 ⎫ 942 ⎬	910 ⎫ 920 ⎬ B	$\frac{1}{2}$	
	966	942 L	$\frac{1}{2}$	Broad.
	985	959 L	1	,,
	1002	972 L	$\frac{1}{2}$	
	1020	987 L		
	1040	1003 B	1	As in ethyl iodide.
	1067	1025 B	1	,, ,,
	1086	1037 B	1	,, ,,
	1135	1072 B	1	,, ,,
	1165	1100 B	1	,, ,,
	1040 ⎫ — ⎬	1003 ⎫ 1120 ⎬ B	$\frac{1}{2}$ to 1	
Formic acid (FRANKLAND).	732	732 L	$\frac{1}{2}$	Broad line of which 732 is the distinct nucleus.
	893 ⎫ 930 ⎬	878 ⎫ 912 ⎬ B	$\frac{1}{2}$	
	930 ⎫ 966 ⎬	912 ⎫ 942 ⎬ B	$\frac{1}{4}$	
	966 ⎫ 973 ⎬	942 ⎫ 948 ⎬ B	$\frac{1}{4}$ to 1	
	968	945		End of spectrum.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Glacial acetic acid (KAHLBAUM).	887 } 900 }	875 } 884 } B	{ 0 to 1 / 1 to $\frac{1}{4}$	
	900 } 907 }	884 } 892 } B	$\frac{1}{4}$	
	907 } 913 }	892 } 898 } B	{ 0 to 1 / 1 to 0	
	930	912 L	$\frac{1}{2}$	
	930 } 949 }	912 } 927 } B	{ 0 to $\frac{1}{2}$ / $\frac{1}{2}$ to 0	
	949	927 L	$\frac{1}{2}$	
	966 } 985 }	942 } 959 } B	{ 0 to 1 / 1 to $\frac{1}{2}$	
	985 } 1010 }	959 } 980 } B	$\frac{1}{2}$	
	1010 } 1024 }	980 } 990 } B	$\frac{1}{2}$ to 1	
	1024	990	..	End of spectrum.
Propionic acid. (KAHLBAUM).	736	736 L	$\frac{1}{2}$	Fuzzy line.
	867	857 L	$\frac{1}{2}$	
	900 } 913 }	884 } 898 } B	$\frac{1}{2}$	
	913 } 917 }	898 } 902 } B	1	
	917 } 942 }	902 } 920 } B	$\frac{1}{2}$	
	1010 } 1061 }	980 } 1020 } B	0 to 1	
	1020	987 L	1	Broad.
	1040	1003 L	1	,,
	1061	1020		End of spectrum.
Isobutyric acid (KAHLBAUM).	893	872 L	1	
	900 } 913 }	884 } 898 } B	$\frac{1}{2}$	
	913 } 917 }	898 } 902 } B	1	
	917 } 930 }	902 } 912 } B	$\frac{1}{2}$	
	1020	987 L	$\frac{3}{4}$	
	1040	1003 B	..	
	1067	1025 B	..	As in ethyl iodide.
	1085	1037 B	..	,, ,,
	1135	1072 B	..	,, ,,
	1020 } 1075 }	987 } 1030 } B	$\frac{1}{2}$	
	1075 } 1103 }	1030 } 1050 } B	$\frac{1}{2}$ to 1	
	1103	1050		End of spectrum.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Valerianic acid (Kahlbaum).	746	745 L	½	Broad line.
	907, 913 }	892, 898 } B	0 to ¼	
	913, 917 }	898, 902 } B	¾ to 1; 1 to ¾	
	917, 930 }	902, 912 } B	¼ to 0	
	949	927 L	½ ½	Very fine.
	971	947 L	½ ½	,,
	1002	972 L	½ ½	,,
	1027	992 L	½	
	1040	1003 L	¾	Broad line.
	1020, 1047 }	987, 1010 } B	0 to 1	
	1047	1010	1	End of spectrum.
Aceto-acetic ether (Hodgkinson).	741	740 L	½	Broad line.
	886	872 L	¼	
	895, 907 }	880, 892 } B	0 to ½	
	907, 913 }	892, 898 } B	¼	
	913, 917 }	898, 902 } B	¾	
	1003	972 L	¼	
	1003, 1133 }	972, 1070 } B	0 to 1	
	1020	987 L	¼	
	1040	1003 L	½	
	1047, 1066 }	1010, 1025 } B	½ to ¾; ¾ to ½	
	1096, 1107 }	1045, 1055 } B	¾ to 1; 1 to ¾	
	1132	1070	1	End of spectrum.
Diethyl aceto-acetic ether (Hodgkinson).	900, 907 }	884, 892 } B	0 to ½	
	907, 913 }	892, 898 } B	¼	
	913, 917 }	898, 902 } B	1	
	917, 922 }	902, 905 } B	½ to 0	
	1003	972 L	¼	
	1020	987 L	½	
	1040	1003 L	½	Broad line.
	1047, 1066 }	1010, 1025 } B	½ to 1; 1 to	
	1020, 1066 }	987, 1025 } B	0 to ½	Background of spectrum.
	1066, — }	1025, 1150 } B	½	,, ,,
	1096, 1107 }	1045, 1055 } B	1 to ½	
	1159, 1171 }	1095, 1105 } B	1 to ½	
	—	1160	1	End of spectrum.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Glycerine (Price's).	915	900 L	1	Fine line.
	915 } 949 } B	900 } 927 } B	$\frac{3}{4}$	
	949 } 985 } B	927 } 959 } B	$\frac{3}{4}$ to 0	
	1002	972 L	1	
	1002 } 1003 } B	972 } 973 } B	$\frac{3}{4}$	
	1003	973	1	End of spectrum.
Benzine (Armstrong).	710	713 L	$\frac{1}{2}$	Fuzzy line.
	862	852 L	$\frac{1}{2}$	
	867	857 L	$\frac{1}{2}$	
	867 } 872 } B	857 } 861 } B	$\frac{1}{4}$	
	872 } 888 } B	861 } 875 } B	{ At 861 to 872, 1; from 872 to 875, 1 to 0	
	915 } 930 } B	900 } 912 } B	{ 0 to $\frac{1}{4}$ / $\frac{1}{4}$ to 0	
	963 } — } B	940 } 1150 } B	0 to $\frac{1}{2}$	{ Shaded gradually as background.
	1002	972 B	1	As in ethyl iodide.
	1020	987 B	1	,, ,,
	1040	1003 B	1	,, ,,
	1066	1025 B	1	,, ,,
	1096 } 1105 } B	1045 } 1052 } B	{ At 1045, 1; from 1045 to 1052, 1 to 0	
	1137 } 1149 } B	1074 } 1084 } B	{ At 1074, 1; from 1074 to 1084, 1 to 0	
	— } — } B	1125 } 1135 } B	{ At 1125, 1; from 1125 to 1135, 1 to 0	
	—	1160	1	End of spectrum.
Phenyl bromide (Hodgkinson).	710	713 L	$\frac{1}{2}$	Fuzzy line.
	867	857 L	$\frac{1}{2}$	
	867 } 872 } B	857 } 861 } B	$\frac{1}{2}$	
	872 } 885 } B	861 } 872 } B	1 to 0	As in benzine.
	963 } — } B	940 } 1150 } B	0 to $\frac{1}{2}$	,, ,,
	1020	987 B	1	,, ,,
	1040	1003 B	1	,, ,,
	1066	1025 B	1	,, ,,
	1096 } 1105 } B	1045 } 1052 } B	1	,, ,,
	1137 } 1149 } B	1074 } 1084 } B	1	,, ,,
	— } — } B	1125 } 1135 } B	1	,, ,,
	—	1160	1	End of spectrum.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Benzyl chloride (HODGKINSON).	711	713 L	$\frac{1}{2}$	Fuzzy line.
	867	857 L	$\frac{1}{2}$	
	867 } 873	857 } 861 B	$\frac{1}{2}$	
	873 } 885	861 } 872 B	1 to 0	As in benzine.
	964 } —	940 } 1150 B	0 to $\frac{1}{2}$	,, ,,
	899 } 907	884 } 892 B	{ 0 to $\frac{3}{4}$ { $\frac{3}{4}$ to 0	
	907 } 913	892 } 898 B	$\frac{1}{4}$	
	913 } 918	898 } 902 B	$\frac{1}{2}$	
	918 } 922	902 } 905 B	$\frac{1}{4}$	
	922 } 930	905 } 912 B	$\frac{1}{2}$	
	1020	987 B	1	As in benzine.
	1040	1003 B	1	,, ,,
	1066	1025 B	1	,, ,,
	1097 } 1105	1045 } 1052 B	1	,, ,,
	1138 } 1149	1074 } 1084 B	1	,, ,,
	— } —	1125 } 1135 B	1	,, ,,
	—	1160	1	End of spectrum.
Aniline (KAHLBAUM).	711 } 720	713 } 722 B	{ 0 to 1 { 1 to 0	
	778 } 781	775 } 777 B	0 to $\frac{1}{4}$	
	781 } 800	777 } 795 B	1	
	800 } 805	795 } 800 B	$\frac{1}{4}$ to 0	
	867	857 L	$\frac{1}{2}$	
	867 } 872	857 } 860 B	$\frac{1}{4}$	
	872 } 889	860 } 875	1 to 0	{ Keeps its maximum to 817.
	930	912 L	$\frac{1}{2}$	Broad.
	967	942 L	$\frac{1}{2}$	,,
	985 } 995	959 } 968 B	1	{ 0 to 1 { 1 to 0
	1020 } 1037	987 } 1000	1	
	1037 } 1040	1000 } 1003 B	1 to $\frac{3}{4}$	
	1040 } 1135	1003 } 1072 B	$\frac{3}{4}$	
	1135	1072 B	1	As in ethyl iodide.
	1135 } 1165	1072 } 1100 B	$\frac{1}{2}$	
	1165	1100	1	End of spectrum.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Dimethyl aniline (HODGKINSON).	867	857 L	$\frac{3}{4}$	
	867 ⎱ 871 ⎰ B	857 ⎱ 860 ⎰ B	$\frac{1}{4}$	
	871 ⎱ 887 ⎰ B	860 ⎱ 875 ⎰ B	1 to 0	⎰ Keeps its maximum ⎱ to 867.
	907 ⎱ 930 ⎰ B	892 ⎱ 912 ⎰ B	⎰ 0 to $\frac{3}{4}$ ⎱ ⎱ $\frac{3}{4}$ to 0 ⎰	⎰ Maximum intensity ⎱ about 898.
	972 ⎱ 995 ⎰ B	947 ⎱ 968 ⎰ B	⎰ 0 to 1 ⎱ ⎱ 1 to 0 ⎰	⎰ Maximum intensity ⎱ about λ 952.
	1040 ⎱ 1061 ⎰ B	1003 ⎱ 1020 ⎰ B	0 to 1	
	1061 ⎱ 1075 ⎰ B	1020 ⎱ 1030 ⎰ B	1	
	1075 ⎱ 1097 ⎰ B	1030 ⎱ 1045 ⎰ B	$\frac{1}{2}$	
	1097 ⎱ 1105 ⎰ B	1045 ⎱ 1052 ⎰ B	1 to $\frac{1}{2}$	
	1118 ⎱ 1132 ⎰	1060 ⎱ 1070 ⎰	$\frac{1}{2}$ to 1	
	1132	1070	..	End of spectrum.
Nitro-benzine (HODGKINSON).	710	713 L	$\frac{1}{4}$	Fuzzy line.
	856 ⎱ 866 ⎰ B	845 ⎱ 856 ⎰ B	$\frac{1}{2}$	
	867 ⎱ 879 ⎰ B	857 ⎱ 867 ⎰ B	$\frac{1}{2}$	
	915	900 L	$\frac{1}{4}$	Broad line.
	949	927 L	$\frac{1}{4}$	,, ,,
	985	959 L	$\frac{1}{4}$	,, ,,
	985 ⎱ 1090 ⎰ B	959 ⎱ 1040 ⎰ B	0 to 1	
	1002	972	$\frac{1}{2}$	Broad line.
	1040	1003	$\frac{3}{4}$	,, ,,
	1066	1025	1	,, ,,
	1090	1040	1	End of spectrum.
Turpentine (commercial).	880 ⎱ 897 ⎰ B	868 ⎱ 882 ⎰ B	0 to $\frac{3}{4}$	
	903 ⎱ 910 ⎰	888 ⎱ 895 ⎰	$\frac{3}{4}$	
	913 ⎱ 918 ⎰	898 ⎱ 902 ⎰	$\frac{3}{4}$	
	925 ⎱ 942 ⎰	908 ⎱ 920 ⎰	1	
	949 ⎱ 958 ⎰	927 ⎱ 935 ⎰	1	
	972	947	$\frac{1}{2}$	
	1002	972	1	Broad line.
	1020	987	1	,,
	1040	1003	1	,,
	1002 ⎱ — ⎰ B	972 ⎱ 1160 ⎰ B	0 to 1	
	1066	1025 B	1	⎰ As in the benzine ⎱ spectrum.
	1100	1047	1	,, ,,
	1145	1080	1	,, ,,
	—	1130	1	,, ,,

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Phenyl-propyl alcohol (HODGKINSON).	716	718 L	¼	
	867 } 873 }	857 } 861 } B	0 to ¼	
	873 } 879 }	861 } 867 } B	1	
	879 } 887 }	867 } 875 } B	½ to 0	
	915 } 921 }	900 } 905 } B	0 to ¼	
	921 } 942 }	905 } 920 } B	{ ¼ to 1 / 1 to ¼	
	942 } 967 }	920 } 942 } B	¼	
	949	927 L	½	
	967 } 992 }	942 } 965 } B	¼ to 0	
	992 } 1011 }	965 } 980 } B	1 to ½	
	1011 } 1040 }	980 } 1003 }	½	
	1040	1003	1	End of spectrum.
Methyl salicylate (HODGKINSON).	710	713	½	Fuzzy line.
	861 } 877 }	851 } 865 }	1	
	892	878 L	¼	
	907 } 925 }	892 } 908 }	{ 0 to ¼ / ¼ to 0	
	966 } 1037 }	942 } 1000 }	0 to 1	
	1037	1000	1	End of spectrum.
Benzyl-ethyl ether (HODGKINSON).	710	713	½	Fuzzy.
	866 } 873 }	856 } 861 } B	0 to ¼	
	873 } 885 }	861 } 872 } B	1	
	885 } 887 }	872 } 875 }	¼ to 0	
	907 } 918 }	892 } 902 }	0 to ¾	
	949 } 985 }	927 } 959 }	{ 0 to ½ / ½ to 0	
	1040	1003 L	1	Broad line.
	1132	1070	1	,,
	1011 } — }	980 } 1160 }	0 to 1	Gradual shade.
	—	1160	1	End of spectrum.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Dibenzyl acetic ether (HODGKINSON).	867	857 L	$\frac{1}{2}$	
	867 } 873	857 } 861 B	0 to $\frac{1}{4}$	
	873 } 885	861 } 872 B	1	
	885 } 887	872 } 875 B	$\frac{1}{4}$ to 0	
	903	888 L	$\frac{1}{2}$	{ The position of this line not quite certain.
	913 } 942	898 } 920 B	0 to $\frac{1}{2}$ / $\frac{1}{2}$ to 0	
	986 } 1102	960 } 1050 B	0 to 1	Background.
	1020	987	1	
	1040	1003	1	
	1102	1050	1	End of spectrum.
Ethylic benzoate (HODGKINSON).	710	713 L	$\frac{1}{4}$	
	732	732 L	$\frac{1}{4}$	
	867	857 L	$\frac{1}{2}$	
	867 } 875	857 } 863	0 to $\frac{1}{4}$	
	875 } 885	863 } 872	$\frac{3}{4}$	
	885 } 887	872 } 875	$\frac{1}{4}$ to 0	
	907 } 913	892 } 898	0 to $\frac{1}{4}$	
	913 } 918	898 } 902	$\frac{1}{2}$	
	1023 } 1061	990 } 1020	0 to 1	
	1061	1020	1	End of spectrum.
Olive oil (commercial).	867	857 L	$\frac{1}{2}$	Fine line.
	895 } 907	880 } 892	0 to 1	
	918 } 958	902 } 935	1	
	958 } 1040	935 } 1003	0 to $\frac{1}{4}$	
	1040	1003	1	End of spectrum.
Allyl alcohol (KAHLBAUM).	873 } 877	861 } 865 B	{ 0 to $\frac{3}{4}$ / $\frac{3}{4}$ to 0	
	885 } 900	872 } 885 B	{ 0 to $\frac{3}{4}$ / $\frac{3}{4}$ to 0	
	930 } 966	912 } 942	0 to $\frac{3}{4}$	
	966	942 L	1	
	966 } 989	942 } 963	$\frac{1}{4}$	
	989 } 1037	963 } 1000 B	$\frac{1}{2}$	
	1045	1010	1	End of spectrum.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Allyl sulphide (Kahlbaum).	873, 877	861, 865 B	0 to $\frac{3}{4}$, $\frac{3}{4}$ to 0	
	893, 900	878, 885 B	0 to $\frac{3}{4}$, $\frac{3}{4}$ to 0	
	921, 936	905, 915 B	0 to $\frac{3}{4}$, $\frac{3}{4}$ to 0	
	966	942 L	1	
	989	963 L	1	
	1061, —	1020, 1160 B	0 to 1	Gradual shading.
	1110	1057 L	1	
	—	1140 L	1	
	—	1160	1	End of spectrum.
Anethol (Hodgkinson).	873, 880	861, 868 B	0 to $\frac{3}{4}$, $\frac{3}{4}$ to 0	
	891, 905	877, 890 B	0 to $\frac{3}{4}$, $\frac{3}{4}$ to 0	
	915, 921	900, 905 B	0 to $\frac{3}{4}$, $\frac{3}{4}$ to 0	
	925, 930	908, 912 B	1	
	1037, 1044	1000, 1006 B	0 to $\frac{3}{4}$, $\frac{3}{4}$ to 0	
	1061, 1119	1020, 1060 B	$\frac{3}{4}$	
	1124, —	1065, 1160 B	$\frac{1}{2}$	
	—	1170	1	End of spectrum.
Citraconic anhydride (Hodgkinson).	710	713 L	$\frac{1}{4}$	
	850	840 L	$\frac{1}{2}$	Broad.
	903, 907	888, 892	0 to $\frac{1}{2}$, $\frac{1}{2}$ to 0	Very steep edges.
	913, 918	898, 902	$\frac{1}{2}$	
	949	927 L	$\frac{1}{2}$	Broad.
	985	959	$\frac{1}{2}$	,,
	1020	987	$\frac{1}{2}$	,,
	1040, 1080	1003, 1033 B	0 to $\frac{1}{2}$, $\frac{1}{2}$ to 0	
	1105, 1157	1052, 1092 B	0 to $\frac{1}{2}$, $\frac{1}{2}$ to 0	
	1040, —	1003, 1120 B	$\frac{1}{4}$	
	—	1120, 1130 B	$\frac{1}{4}$ to 1	
	—	1130	1	End of spectrum.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Chloroform (commercial).	720	722　L	$\frac{1}{2}$	
	732	732　L	$\frac{1}{2}$	
	774	772　L	$\frac{1}{2}$	
	792	788　L	$\frac{1}{2}$	
	813	808　L	$\frac{1}{2}$	
	833	824　L	$\frac{1}{2}$	
	846	837　L	$\frac{1}{4}$	
	867	857　L	$\frac{1}{4}$	
	892	878　L	1	{ Broad and sharp at edges.
	907	892	$\frac{1}{2}$	
	930	912　L	$\frac{1}{2}$	
	949	927　L	$\frac{1}{2}$	
	985	959　L	$\frac{1}{2}$	
	1011	980	$\frac{1}{2}$	
	1066	1025	1	{ Broad and sharp at edges.
	1165	1100	1	,,　　　　,,
	—	1180	1	,,　　　　,,
	—	1200	1	End of spectrum.
Hydrochloric acid, 6 inches (HOPKIN and WILLIAMS).	732	732　L	$\frac{1}{4}$	These lines are very faint and would escape notice under ordinary circumstances.
	741	740　L	$\frac{1}{4}$	
	845	836　L		
	867	857　L	$\frac{1}{4}$	
	949	927　L	$\frac{1}{4}$	
Ammonia, ·880 (HOPKIN and WILLIAMS).	732	732　L	$\frac{1}{2}$	{ Broad line with nucleus.
	774	772　L	$\frac{1}{2}$	,,　　　　,,
	796 / 799	792 / 795 } B	1	
	885	872　L	$\frac{1}{2}$	
	895 / 903	880 / 888 } B	0 to $\frac{1}{4}$	
	903 / 907	888 / 892 } B	1	
	907 / 913	892 / 898 }	$\frac{1}{4}$ to 0	
	915	900　L	1	{ Fuzzy joining previous band, but having a distinct nucleus.
	934 / 949	915 / 927 } B	{ 0 to 1 / 1 to $\frac{1}{2}$	
	949 / 999	927 / 970 } B	$\frac{1}{2}$	
	972 / 985	947 / 959 } B	{ $\frac{1}{2}$ to 1 / 1 to $\frac{1}{2}$	
	999 / 1011	970 / 980 }	$\frac{1}{2}$ to 1	
	1011	980	..	End of spectrum.

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
Nitric acid, 1·360 (HOPKIN and WILLIAMS).	774	772 L	$\frac{1}{2}$	Broad line with nucleus
	845	836 L	$\frac{1}{2}$	,, ,,
	895} 942}	880} 920} B	$\frac{1}{4}$	
	942} 949}	920} 927} B	{ 0 to 1, 1 to $\frac{1}{2}$	
	949} 1011}	927} 980} B	$\frac{1}{2}$	Background.
	985} 1002}	959} 972} B	{ $\frac{1}{2}$ to 1, 1 to $\frac{1}{2}$	
	1011} 1037}	980} 1000}	$\frac{1}{2}$ to 1	
	1037	1000	1	End of spectrum.
Sulphuric acid.	799	795 L	$\frac{1}{4}$	
	813	808 L	$\frac{1}{4}$	
	867	857	$\frac{1}{4}$	
	882} 975}	870} 950}	$\frac{1}{4}$ 0 to 1	
	975	950	. .	End of spectrum.
Water, 6 inches.	732} 833}	732} 824} B	$\frac{1}{4}$	{ Traces of a line at both 732, 824.
	833} 942}	824} 920} B	{ Gradual shading from $\frac{1}{2}$ to $\frac{3}{4}$ }	Traces of a line at 920.
	942} 984}	920} 958} B	1	Traces of a line at 959.
	984} 1000}	958} 970}	$\frac{3}{4}$	
	1000} 1004}	970} 974}	1	{ The central part shows line 972.
	1004} 1045}	974} 1010}	$\frac{3}{4}$	1010 end of spectrum.
Water, 2 feet.	732	732 L	$\frac{3}{4}$	
	732} 833}	732} 824}	{ Band shading from $\frac{1}{2}$ to $\frac{1}{4}$	
	833	824 L	$\frac{3}{4}$	

Compound.	Lines (L) and bands (B).			
	Approximate wave-length.	Scale on plates.	Intensity.	
$\frac{2}{3}$ alcohol, $\frac{1}{3}$ benzine.	710	713 L	$\frac{1}{2}$	
	741	740 L	$\frac{1}{2}$	
	867	857 L	$\frac{3}{4}$	
	873 } 885 }	861 } 872 } B	$\frac{3}{4}$	
	907 } 921 }	892 } 905 } B	0 to 1	
	930	912 L	$\frac{1}{4}$	
	958	935 L	$\frac{1}{2}$	Broad line.
	985 } 1105 }	959 } 1052 } B	$\frac{1}{2}$	Trace of line at 959.
	1002	972 L	$\frac{3}{4}$	
	1020	987 L	$\frac{3}{4}$	
	1037 } 1044 }	1000 } 1008 } B	$\{$ $\frac{1}{2}$ to $\frac{3}{4}$ $\frac{3}{4}$ to $\frac{1}{2}$	
	1075 } 1090 }	1030 } 1040 } B	$\{$ $\frac{1}{4}$ to $\frac{3}{4}$ $\frac{3}{4}$ to $\frac{1}{2}$	
	1097 } 1105 }	1045 } 1052 } B	$\{$ $\frac{1}{2}$ to $\frac{3}{4}$ $\frac{3}{4}$ to $\frac{1}{2}$	
	1105 } 1124 }	1052 } 1065 }	$\frac{1}{2}$ to 1	
	1124	1065	1	End of spectrum.

700   800   900   1000   1100   1200

Methyl Alcohol

Ethyl Alcohol

Propyl Alcohol

Iso propyl Alcohol.

Pseudo butyl Alcohol

Iso butyl Alcohol

Amyl Alcohol

Methyl Iodide

Ethyl Iodide

Ethyl Bromide

Propyl Iodide

Amyl Iodide

Amyl Bromide

Hexyl Iodide

600   700   800   900   1000

Chloroform.

Hydrochloric acid

Ammonia

Nitric acid

Sulphuric acid

Water (6 ins.)

Water (2 feet)

700 800 900 1000 1100 1200

Aldehyde

Paraldehyde

Diethyl Ether

Amyl Ether

Ethyl Nitrate

Ethyl Oxalate

Ethyl Sulphide

Amyl Nitrite

Formic acid

Acetic acid

Propionic acid

Isobutyric acid

Valerianic acid

Aceto Acetic Ether

Di-ethyl aceto acetic Ether

Glycerine

700　　　800　　　900　　　1000　　　1100　　　1200

Benzine

Phenyl Bromide

Benzyl Chloride

Aniline

Dimethyl Aniline

Nitro Benzine

Turpentine

Phenyl propyl Alcohol

Methyl Salicylate

Benzyl-ethyl Ether

Dibenzyl acetic Ether

Ethylic Benzoate

Olive Oil.

Allyl Alcohol

Allyl Sulphide.

Anethol

Citra-conic anhydride